Title: Building a Moon Colony

Brief Overview:

The students will be able to draw a scale model of a living quarters. Each group will be given a budget, choice of building site, and choice of building materials. The ultimate goal is to build a safe, comfortable, and affordable scientific compound under a time constraint.

Links to NCTM Standards:

- **Mathematics as Problem Solving**
  Students will demonstrate their ability to solve problems using various strategies including problems with open-ended answers, problems which are solved in a cooperative atmosphere, and problems involving working within a budget according to restrictions set forth by the administration.

- **Mathematics as Communication**
  Students will demonstrate their ability to communicate mathematically and scientifically. The students will write and discuss their reasons for choosing a building site and the materials used.

- **Mathematics as Reasoning**
  Students will demonstrate their ability to reason mathematically by locating their site given data on meteor strikes. This data will aid in choosing the site, building materials, and actual construction of their dwelling. They will make conjectures and collect evidence to support a decision.

- **Mathematical Connections**
  Students will demonstrate their ability to connect mathematics topics within the discipline and within science. Statistical information will be extracted from moon environmental occurrences to determine building sites. The physical properties of metals with significant cost and weight differences will be used to compute project budget and design.

- **Number and Number Relationships**
  Students will demonstrate their ability to apply ratios and proportions in the scale construction of their moon colony. Students will also plot meteor hits and identify points on a coordinate axis.

- **Computation**
  Students will calculate the total cost and total weight of materials. Students will calculate the number of trips needed to complete their project.

- **Statistics**
  Students will demonstrate their ability to analyze data and draw conclusions about the placement of a site on a Cartesian plane.

- **Measurement**
  Students will demonstrate their ability to adequately represent a scale model on graph paper with a designated scale.

- **Geometry**
  Students will demonstrate their ability to plot and identify coordinates of points on a coordinate axis. Students will be able to construct a 3-D model of their colony.

Grade/Level:

7 - 8

Duration/Length:

7 to 8 days (variable)

Prerequisite Knowledge:

Students should have working knowledge of the following:

- Rules for proportions and ratios
- Plotting and identifying ordered pairs on a coordinate plane
- Rules for frequency
- Concept of area
- Relative frequency
- Rules for metric measure

Objectives:

Students will:

- solve for ratios, proportions and metric measure.
- work cooperatively in groups of two or three.
- plot and identify ordered pairs on a coordinate plane.
- use ratios and proportions.
- identify ordered pairs.
- compute relative frequency.
- work with metric measures.
- compare physical properties of metals and deduce the most advantageous choice.
- construct a 3-D model of their building.
- make informed decisions based on data.
- adhere to set restrictions while still accomplishing a set goal.

Materials/Resources:

- Paper
- Pencil
- Grid paper
- Metric ruler
- Calculator (optional)
- Index cards
- Masking tapes
- Scissors

Development/Procedures:

Day 1:

- Handout Worksheet #1. Allow time to clarify any questions they may have.
- Organize the class into groups of 2 - 3.
- Discuss Research section with the class and collect Worksheet #1 by end of day.

Day 2:

- Handout Worksheet #2 and a few sheets of graph paper.
- Students will work on this worksheet for 3 - 4 days.

Days 3 and 4:

- Students will continue to work on projects.
- Groups will design floor plans and budgets.

Day 5:

- Students will continue to work on floor plans and budgets.
- By the end of the day, Worksheet #2 should be turned in.

Day 6:

- Handout Worksheet #3.
- Groups will construct 3-D model.

Day 7:

- Groups will finish model and turn it in.
- Handout Worksheet #4 and collect by end of day.
- Students will write a concluding paragraph for homework.

Performance Assessment:

Assessment will be a combination of individual activities and final evaluation of moon colony budget, construction, and design. Neatness and project feasibility will also be taken into account. Each student will write a concluding paragraph explaining why they chose their type of building material and room designs for their moon colony.

Extension/Follow Up:

Over a period of 1-2 months, each student will work on a radio program that will be broadcast to encourage people to visit their moon colony. They must give reasons and incentives to get people to want to try this experience.

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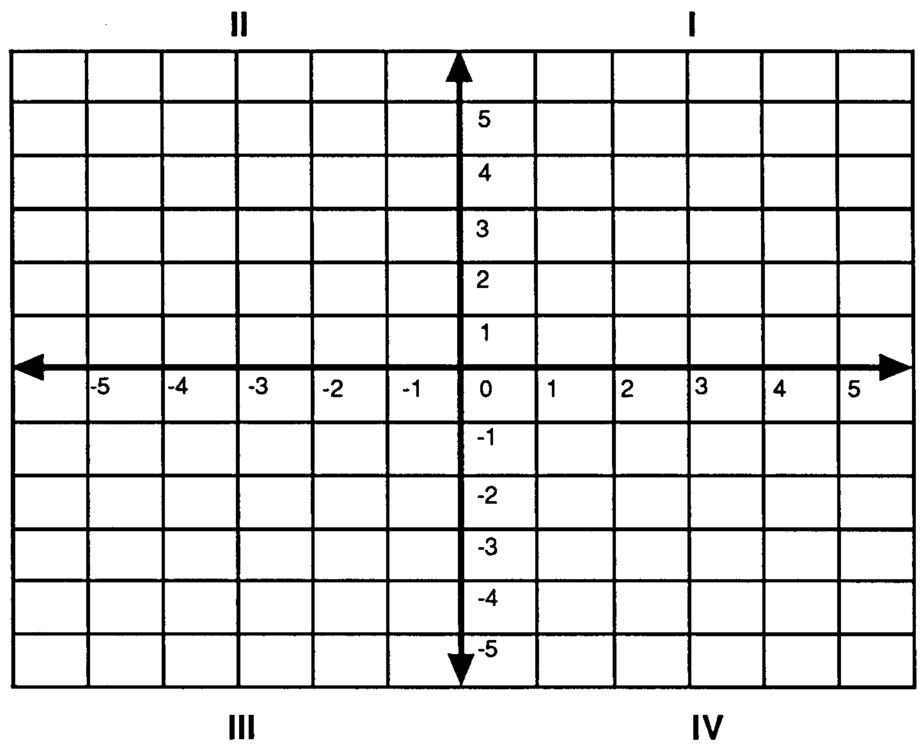
WORKSHEET #1

The first step in building your moon colony is to choose a location to build. The following table lists the year and coordinates of several meteor and asteroid hits on the surface of the moon in the NASA target construction area. Your group will build its colony in any one of the four quadrants depending on the estimated topography of the area and the frequency of hits. Each group member needs to plot the hits on his/her own coordinate axis provided at the bottom of the page and analyze the data points to decide the group's construction site.

YEAR OF HIT	COORDINATES OF HIT	YEAR OF HIT	COORDINATES OF HIT
1938	(1,1)	1972	(-4,-4)
1939	(-3,5)	1977	(-4,5)
1942	(-6,-1)	1981	(-6,-4)
1951	(-4,-2)	1985	(3,0.5)
1951	(-1,-1)	1988	(3,-6)
1952	(6,-6)	1988	(-4,-2)
1954	(5,-4)	1992	(-5,0)
1954	(5,-5)	1996	(3,-0.5)
1956	(4,3)	1997	(5,1)
1968	(-2,3)	1998	(-6,1)
1970	(-3,-2)	1998	(2,3)
1972	(3,5)	1999	(5,-1)

NOTE: The scale on the coordinate axis below and the units on the above coordinates are in Kilometers.



Data Analysis:

1) What was the relative frequency of hits in quadrant I? ______________
2) What was the relative frequency of hits in quadrant II? _____________
3) What was the relative frequency of hits in quadrant III? ____________
4) What was the relative frequency of hits in quadrant IV? ____________
5) What quadrant does your group wish to build in and why was this quadrant chosen? Please explain.

____

____

____

6) Give the perimeter coordinates of the area you wish to build your moon colony.

____

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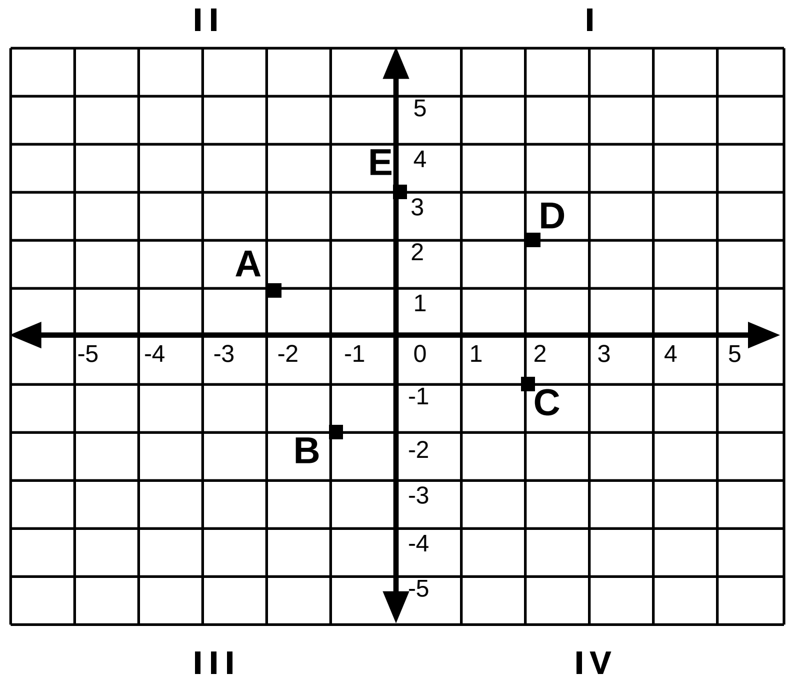
INDIVIDUAL ASSESSMENT:

Before your group of expert aerospace engineers was requested to create a solution for the moon colony construction project, a previous team decided to place a colony at the below location on the coordinate axis. Give the coordinates of the colony's perimeter vertices.

1) **A** (,) **B** (,) **C** (,) **D** (,) **E** (,)



2) Connect the coordinate points A,B,C,D, and E. What figure does it form?

____

Worksheet #2

The next step in constructing your moon colony is to decide upon what materials you will need to get the job done and how to get the materials to the site your group selected. Be careful! NASA needed to cut spending this year, so you are on a fixed budget, and you can NOT go over your budget. Your project can not exceed $2,000,000 (two million dollars).

This budget only includes funds for the structure itself and the transportation requirements. Other items such as food, furniture, kitchen-ware, laboratory supplies, salaries, etcetera will be included in other aerospace colony development budgets. Along with the budget constraint, there is a time constraint. You must build the colony in one year, for after this time, NASA will need to focus shuttle mission use on the Mars program and the Hubble Space Telescope. The shuttle is at your disposal twice a month. The Shuttle can carry at most 29,545 kilograms of payload per trip. The transportation cost for each trip is $100,000.

You will need to research the following 4 metals for building materials in order to decide which metal to use: Lead (Pb), Titanium (Ti), Aluminum (Al), or Iron (Fe).

You will also need to decide how much metal your group needs to construct a safe and comfortable living quarters for the moon colony crew. The crew will consist of 6 individuals.The moon colony should have at least 750 square meters of living and working space and at most 1000 square meters of living and working space. The dwelling must be one story and the materials purchased will be modular in nature. Modular means that the walls are prefabricated, or premade, and they merely snap and/or slide together with a perfect air-tight fit without any adhesive or external connectors, i.e.,: nails or screws. The Metal's Price and Weight Table, on the next page, provides the costs of the various prefabricated dwelling components as well as the weight of each component part. Modular pieces with solar paneled windows and doors cost more than walls themselves. Prices for different types of metal depend only upon the ease with which they may be obtained from its various sources and industries - NOT upon the physical properties inherent in the metals themselves which you will research.

The group can either design the floor plan first or choose the desired metal or metals first. The floor plan must include living quarters, dining facilities, restrooms, work areas, laboratories, storage, and air and water supply room. (These areas must be labeled on the floor plan). The group is free to add any other amenities desired such as workout facilities or a gymnasium. Remember, the more you add to the colony, the more expensive and the more trips the group will need to take in order to transport materials.

The scale for the floor plan of the colony will be every 1.3 cm on a grid provided to the group will equal 1.5 meters of actual measure. Use the attached grid paper to your design your floor plan. Put actual dimensions on the floor plan your group designs. The group will use 3 x 5 index cards to construct the walls of their moon facility. Use scale proportions for the linear measure of your compound but do not alter the 3 inch height of the card.

Wall panels, wall panels with windows, and wall panels with doors all come in sheets that are 2 meters wide, 3 meters high, and 0.5 meters thick. Roof modules come in sheets that are 3 meters by 3 meters by 0.5 meters.

The Metal's Price and Weight Table

Construction Component	Cost	Weight (kg)
Iron (Fe)		
Prefabricated internal wall panel	$350.00	2727
Prefabricated external wall panel	$500.00	2727
Prefabricated panel w/solar window	$1000.00	2727
Prefabricated panel with int/ext door	$750.00	2727
Roof modules	$1200.00	3181
Lead (Pb)		
Prefabricated internal wall panel	$450.00	3636
Prefabricated external wall panel	$600.00	3636
Prefabricated panel w/solar window	$1100.00	3636
Prefabricated panel with int/ext door	$875.00	3636
Roof modules	$1350.00	4090
Aluminum (Al)		
Prefabricated internal wall panel	$500.00	909
Prefabricated external wall panel	$800.00	909
Prefabricated panel w/solar window	$1350.00	909
Prefabricated panel with int/ext door	$925.00	909
Roof modules	$1500.00	1363
Titanium (Ti)		
Prefabricated internal wall panel	$650.00	1818
Prefabricated external wall panel	$975.00	1818
Prefabricated panel w/solar window	$1500.00	1818
Prefabricated panel with int/ext door	$1150.00	1818
Roof modules	$1750.00	2272
(Description, cost and weight are per one unit)		

Each group should work on their floor plan and budget. Each group should construct a table on another sheet of paper of your group's total cost and weight of your material choices. Attach tables to Worksheet #2. Each group also should attach the information on the building materials.

1) What is the total amount of each type of panel needed for your group's project?

2) How much do the materials for your group's project cost?

3) How much do the materials for your group's project weigh?

4) How much does the transportation of the materials cost?

5) How many trips will the space shuttle need to take in order to complete the project?

6) What amount of your budget was left over?

Worksheet #3

Now that the floor plan has been designed and all materials purchased, construction is now ready to begin.

1) Each group should cut panels (index cards) into desired lengths scaled to the floor plan design. Include exterior and interior walls.

2) Each group should tape the cards together with tape.

3) Each group should construct roof but do **not** tape roof to the exterior walls so that the interior may be observed.

Worksheet #4

Congratulations! Your moon colony is a success; the crew is thriving and have developed advances since their arrival nine months ago.

One Month Later

Regretfully the moon colony compound was struck by a meteor approximately one meter in length. Unfortunately, NASA lost the metal specifications for your floor plan. Can you please tell us what materials were used. We have not been able to make radio contact with the colony due to the hit and we do not know if anyone has survived. Our best estimate of the force of impact was 2.72 on the Hoffman/Hand scale. Take into account the following Hoffman/Hand values of impact-resistance:

aluminum	1.20
iron	2.65
titanium	3.90
lead	4.10

In Class:

1) Did your group's colony survive the impact? Why or why not?

2) How would the colony have survived an impact of 4.5?

Homework:

Write a paragraph explaining why you chose your building material and the designs for your rooms. Could you have improved on these and why?

Thank you for your quick assistance in this matter.

Worksheet #1

Scoring Rubric

Coordinate axis

Score	Number Correct
4	20 - 24
3	16 - 19
2	12 - 15
1	8 - 11
0	0 - 7

Data Analysis

#1 - 4 are 1 point each; #5 is 2 points; #6 is 2 points

Score	Number Correct
3	7 - 8
2	5 - 6
1	3 - 4
0	0 - 2

Individual Assessment

Score	Number Correct
2	5 - 6
1	3 - 4
0	0 - 2

Worksheet #2

Scoring Rubric

Category	Score	Criteria
a. Information on building material	2	included and accurate
	1	included and mostly accurate
	0	not included
b. Total living area	1	meets requirements
	0	fails to meet requirements
c. Required rooms	1	all included
	0	some not included
d. Actual dimensions	4	all included and accurate
	3	all included and mostly accurate
	2	some included and accurate
	1	some included and mostly accurate
	0	not included
e. Scale for floor plan	2	used accurately
	1	mostly used accurately
	0	not used accurately

Scoring Rubric

Budget of Cost and Payload

Category	Score	Criteria
a. Tables of cost and weight	3	included and accurate
	2	included and mostly accurate
	1	included and somewhat accurate
	0	not included
b. Total amount of materials	3	accurate
	2	mostly accurate
	1	somewhat accurate
	0	not accurate
c. Transportation costs	1	accurate
	0	not accurate
d. Number of trips needed	1	accurate
	0	not accurate
e. Costs fall within budget	1	yes
	0	no
f. Timeframe	1	within restrictions
	0	not within restrictions

Worksheet #3

Scoring Rubric

Score	Criteria
3	The structure is neat with walls matching specified floor plan designations. Walls are trimmed to scale. roof is not attached. Structure conforms to all stated restrictions.
2	The structure is fairly neat with walls corresponding to floor plan. Walls are adequate size. Roof is not attached. Structure conforms to restrictions.
1	The structure is in fair condition. Walls may not meet floor plan designations exactly. Roof may be attached. Structure may not meet restrictions.
0	The structure is unacceptable. Walls do not correspond to the floor plan. Roof is poorly assembled. Structure does not meet restrictions.

Worksheet #4

Scoring Rubric

Category	Score	Criteria
a. In class	2	The student is able to explain in complete sentences why or why not his/her group structure was triumphant or met grotesque defeat and can give a reasonable guess for a structure to withstand a 4.5 impact.
	1	The student attempts to explain why or why not his/her group structure was triumphant or met grotesque defeat and can attempt to give a reasonable guess for how a structure could withstand a 4.5 impact.
	0	The student has no clue as to explaining either what happened to his/her groups structure nor a guess for how a structure could withstand a 4.5 impact.
b. Homework	2	The student uses complete sentences to defend his/her reasons for choosing building materials and room designs, and gives reasonable improvements for his/her colony.
	1	The student uses complete sentences to somewhat defend his/her reasons for choosing building materials and room designs, and gives somewhat reasonable improvements for his/her colony.
	0	The student has no clue why he/she chose the building materials and design or what improvements could be made.